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Title: APS/IARPA EuXFEL/DESY Visit

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Intended for: APS/IARPA EuXFEL/DESY Visit

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APS/IARPA EuXFEL/DESY Visit

& other detector needs

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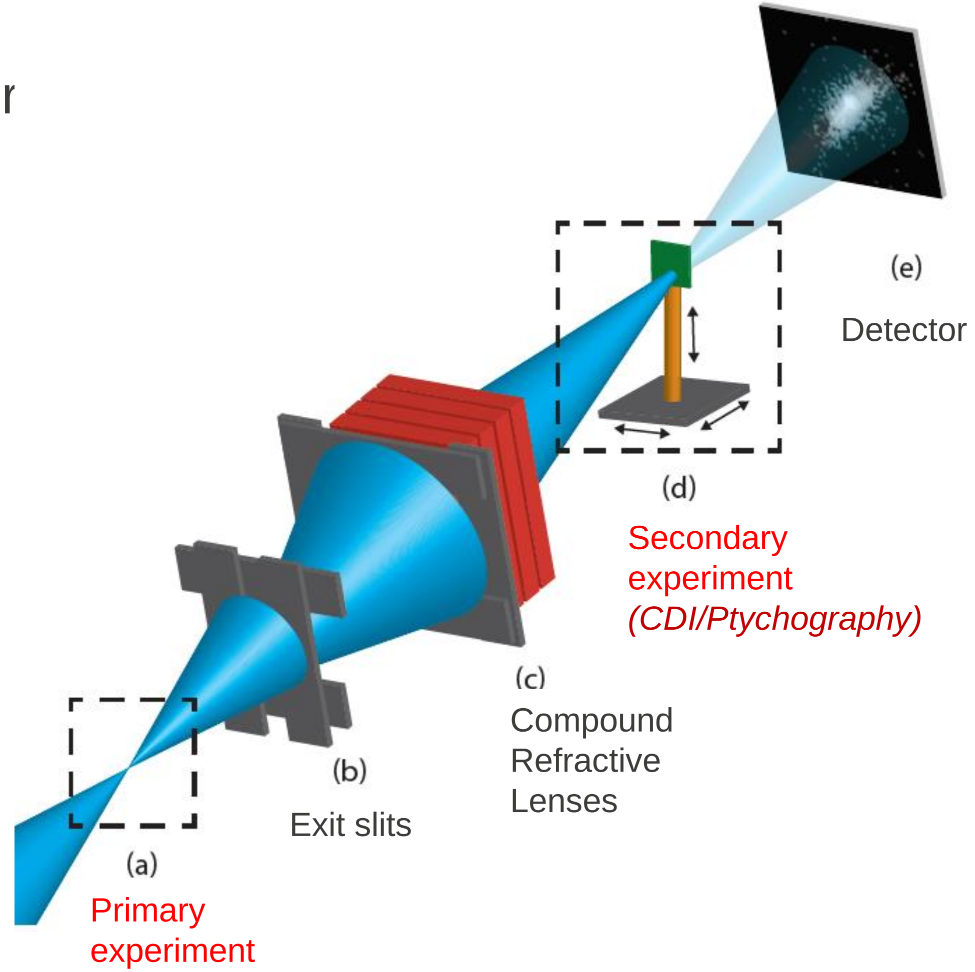
March 5, 2020

Thanks to Zhehui Wang, Jen Bohon and Rich Sheffield

CDI imaging experiments at LCLS

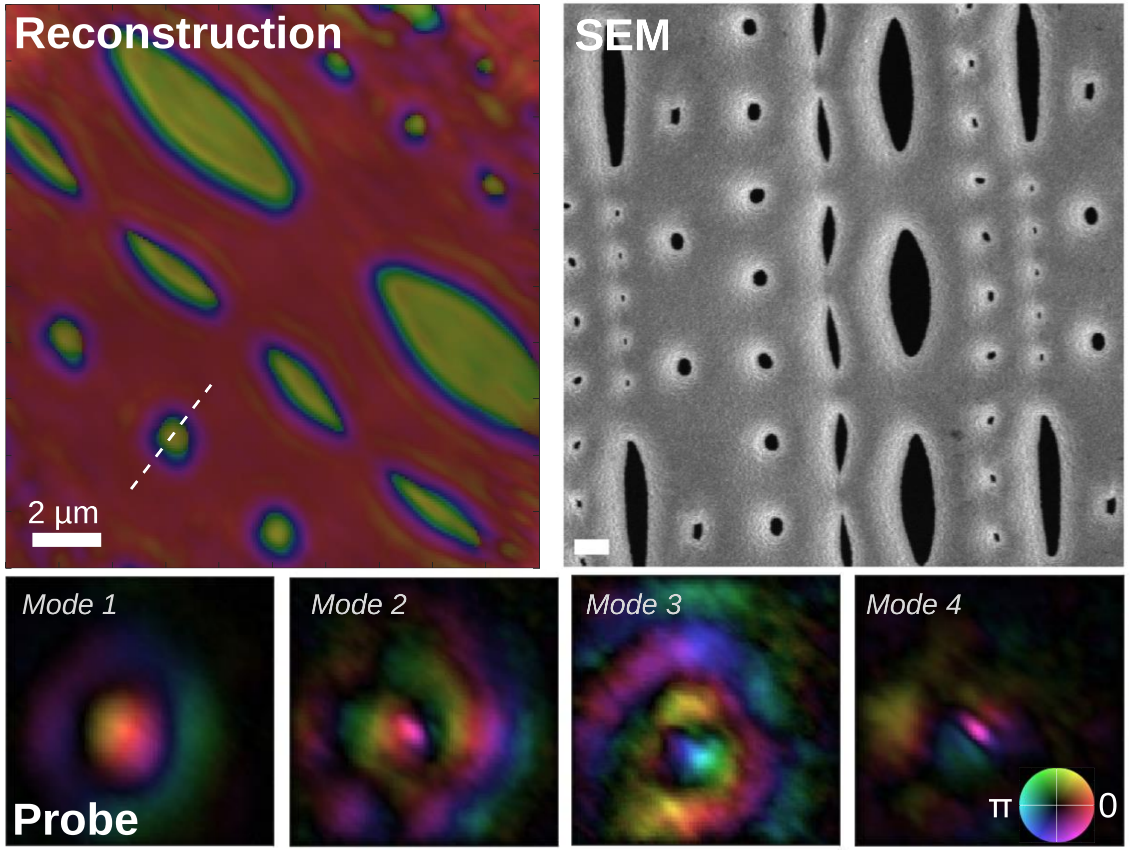
- Parasitic Mode CDI at CXI
  - Evaluation & demonstration of inline parasitic mode oper
  - Demonstration of rapid beam characterization
  - Leveraged experiment to evaluate imaging quality
- Experimental Setup
  - Unused 100nm focused beam (a)
    - Primary experiment was protein crystallography
    - Secondary experiment received downstream "used" beam
  - Slits to limit fill on lens. Beam attenuation (b)
  - Overfilled Be CRL (c)
  - Coated TEM Sample on linear translation stage (d)
  - CSPAD 140k Detector (e)
  - 500 nm Step size, 5 um focused spot on sample



B. Pound et al, Journ. App. Cryst. *In prep.*

Parasitic Beam gives high quality ptychographic reconstruction

- Ptychographic reconstructions based upon ePIE and ePIE derived variants
  - Multi-mode and position refinement additions enabled high quality reconstructions
- Object and probe retrieved with good Object agreement to SEM
  - Thickness variation real (TEM grid strained during deposition)
- Demonstrated ~155 nm resolution
- Beam quality diagnostic in addition to imaging technique



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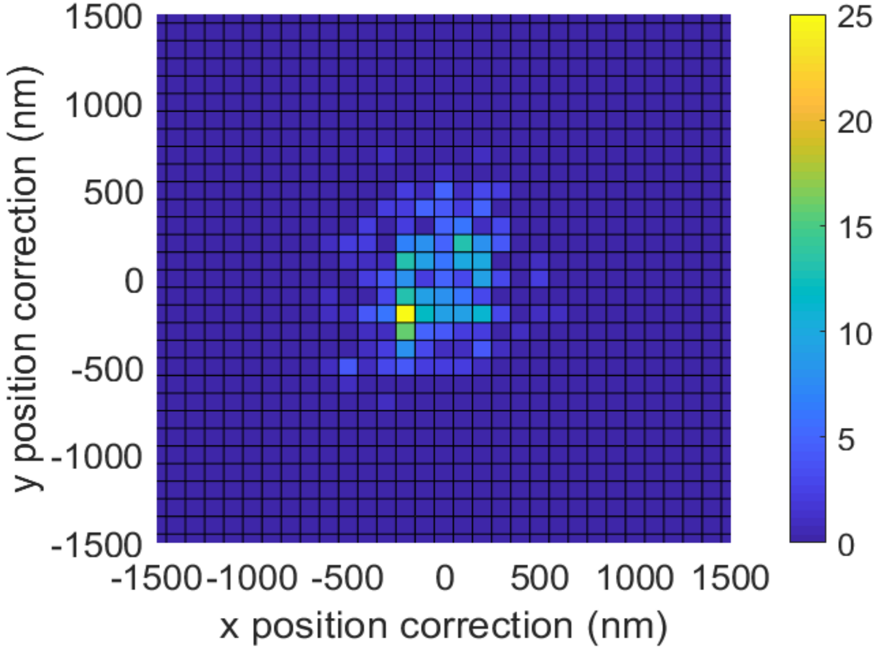
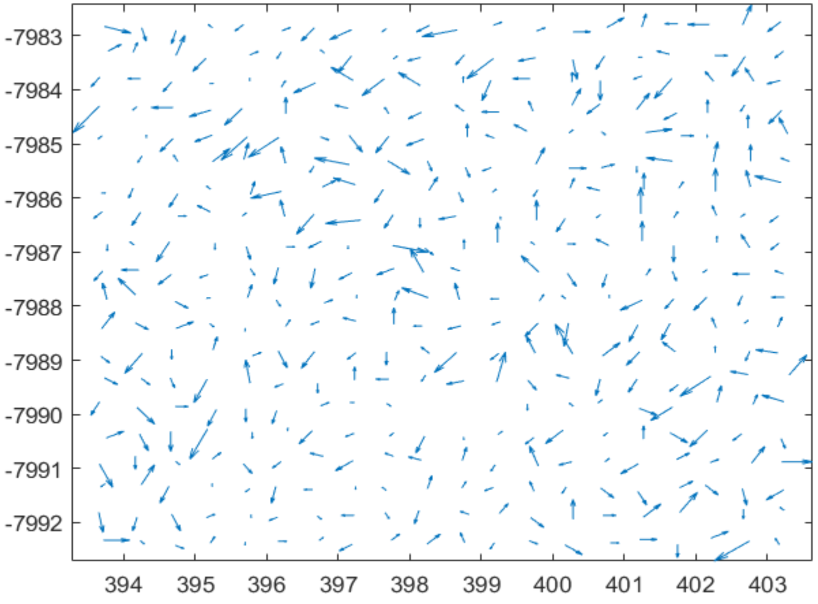
Beam jitter impacts reconstruction ease and quality

- Beam position and profile varied significantly shot to shot
- Experiment was run in a mode where one frame was captured per position & beam shot
- Ptychography requires knowledge of where the beam is hitting the sample for every frame
  - Some position jitter can be compensated for algorithmically but increases computational intensity & there is a limit as to how much can be compensated for
- In-situ beam monitoring would be greatly advantageous

Degree of position refinement needed

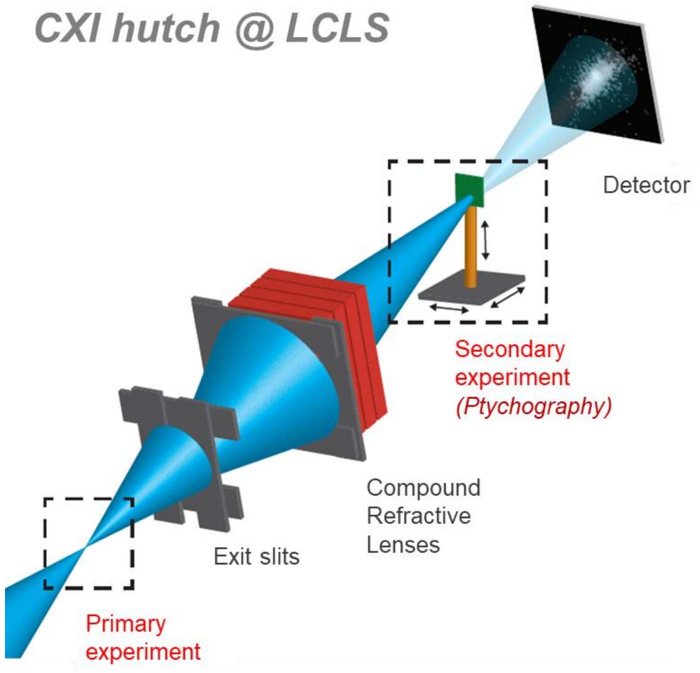


Original and final positions for each frame



Lessons From Imaging at CXI

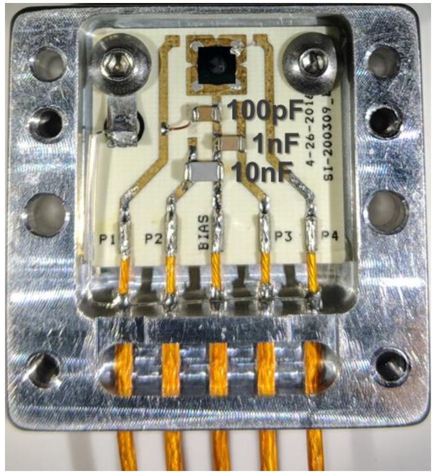
- Successes
  - Imaging in parasitic mode possible
    - High coherence beam maintained through full parasitic geometry
  - Ptychographic results provide rapid beam diagnostics
  - Possible additional operational model for beamline
    - **Opportunity to increase number of users via simultaneous experiments**
- Limitations
  - Experimental non-idealities increase processing complexity
    - Random beam dropout from primary experiment
    - Stability of beam position
  - Judicious hardware selection required for experimental precision
    - Impact of harmonics, choice of undulators, etc.
  - Dynamic range of detector highly limiting resolution



B. Pound et al, Journ. App. Cryst. *In prep.*

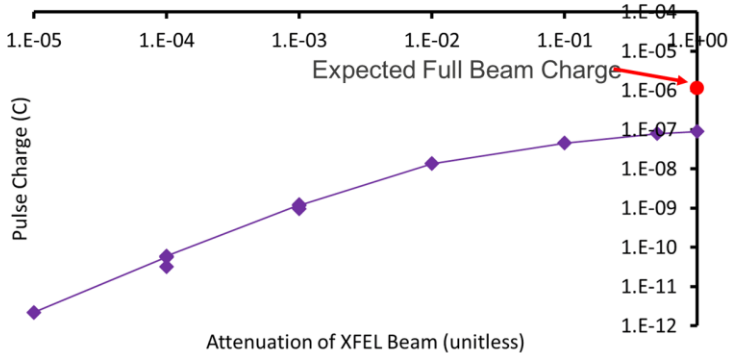
Diamond Detectors Show Promise for Pulse-by-pulse Measurement of XFEL Beams

- Assisted commissioning of Bernina beamline, SwissFEL
- Prototype diamond-based detectors exhibited pulse-by-pulse linearity up to ~3% of the full beam
- Sub-ns response times
- Pulse broadening with increased charge density
- Redesign for faster charge collection: plan for testing at LCLS in 2020

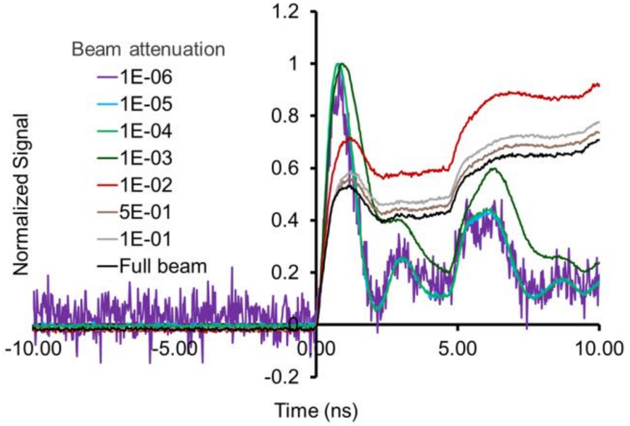


Single Crystal Diamond ~20 µm thick
Contacts: 500 nm UNCD + 15 nm Al
~3 mm diameter active area

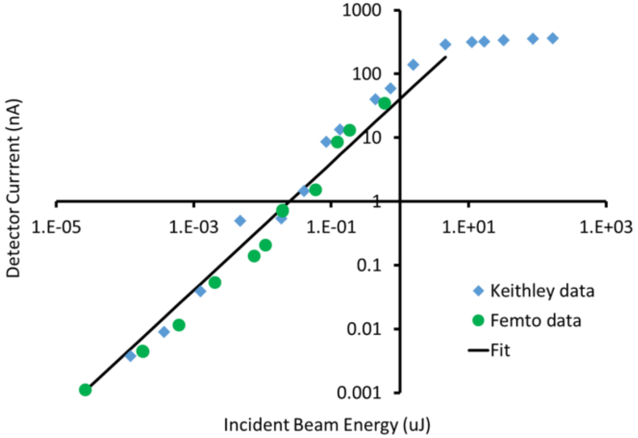
Shot-by-shot Charge



Temporal profile Shot-by-shot Current

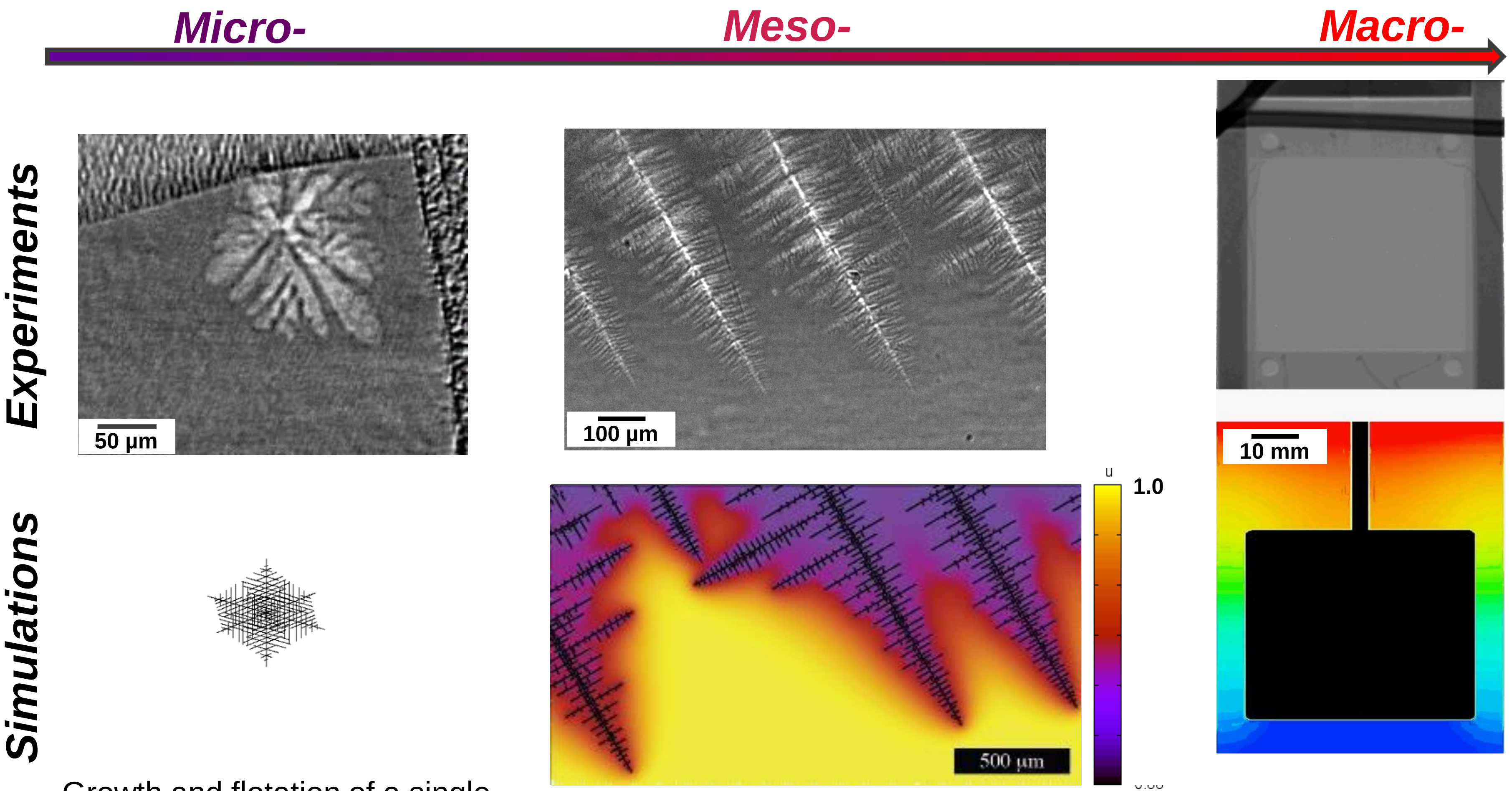


Integrated Current



Bohon et al, in preparation *Juranic et al. (2019) JSR 26, 2081*

MaRIE requires penetrating multiple probes at varying space/time scales to make movies of unique events



Growth and flotation of a single aluminum-rich dendrite

Aluminum-rich dendritic array growth

Tin-bismuth alloy filling casting mold

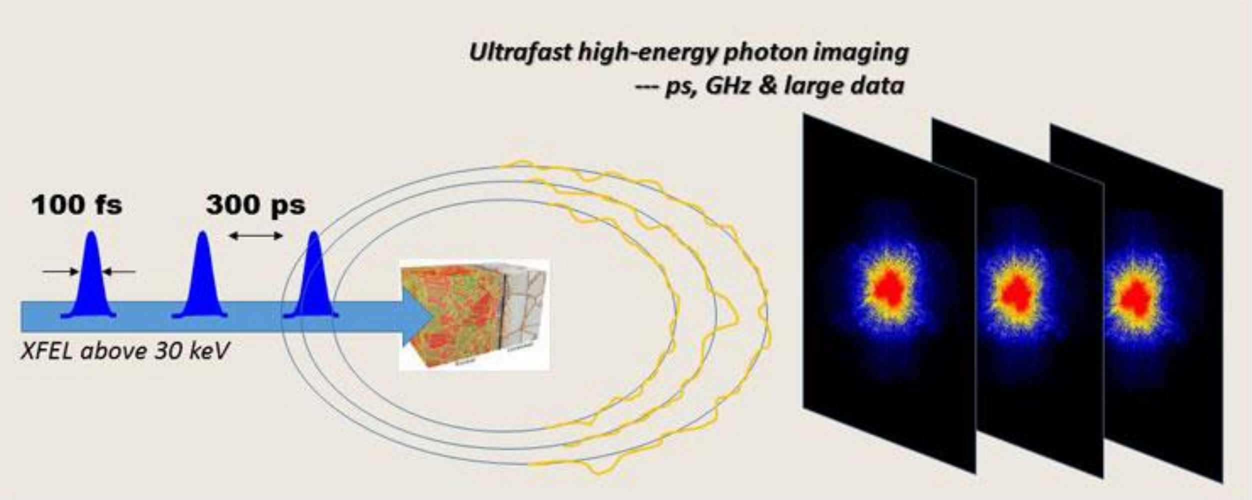
A.J. Clarke (PI), S.D. Imhoff, P.J. Gibbs, pRad Team (LANL)
A. Karma, D. Tourret (Northeastern Univ.),

The August 2016 workshop surveyed current status And identified future opportunities

High–energy and Ultrafast X–Ray Imaging Technologies and Applications

A MaRIE workshop shining a light on the future of ultrafast high–energy photon technology

ACCOMMODATIONS | ABSTRACTS | REGISTRATION | PROGRAM | TRAVEL



High–energy and Ultrafast X–Ray Imaging Technologies and Applications

Date : August 2–3, 2016
Hotel venue: Hilton Santa Fe at Buffalo Thunder

The goal of this workshop is to gather leading experts in the fields related to ultrafast high–energy photon imaging and prioritize the path forward for ultrafast hard x–ray imaging technology development, identify important applications in the next 5–10 years, and establish foundations for near–term R&D collaboration.

This workshop is one in a series being organized by Los Alamos National Laboratory to engage broader scientific community in the MaRIE (Matter–Radiation Interactions in Extremes) development process. MaRIE is the proposed

Local Organizers

- Michael Stevens
- Zhehui (Jeff) Wang
  (505) 665–5353

Meeting Planner

- Peggy Vigil
  (505) 667–8448
  For logistical purposes and questions

External Co–Organizers

- Peter Denes (LBL)
- Sol Gruner (Cornell Univ.)

Thanks to Z. Wang

Two-pronged development process: (Low & High Risk)

Performance	Type I imager	Type II imager
X-ray energy	30 keV	42-126 keV
Frame-rate/inter-frame time	0.5 GHz/2 ns	3 GHz / 300 ps
Number of frames	10	10 - 30
X-ray detection efficiency	above 50%	above 80%
Pixel size/pitch	≤ 300 mm	< 300 mm
Dynamic range	10^3 X-ray photons	≥ 10^4 X-ray photons
Pixel format	64 x 64 (scalable to 1 Mpix)	1 Mpix

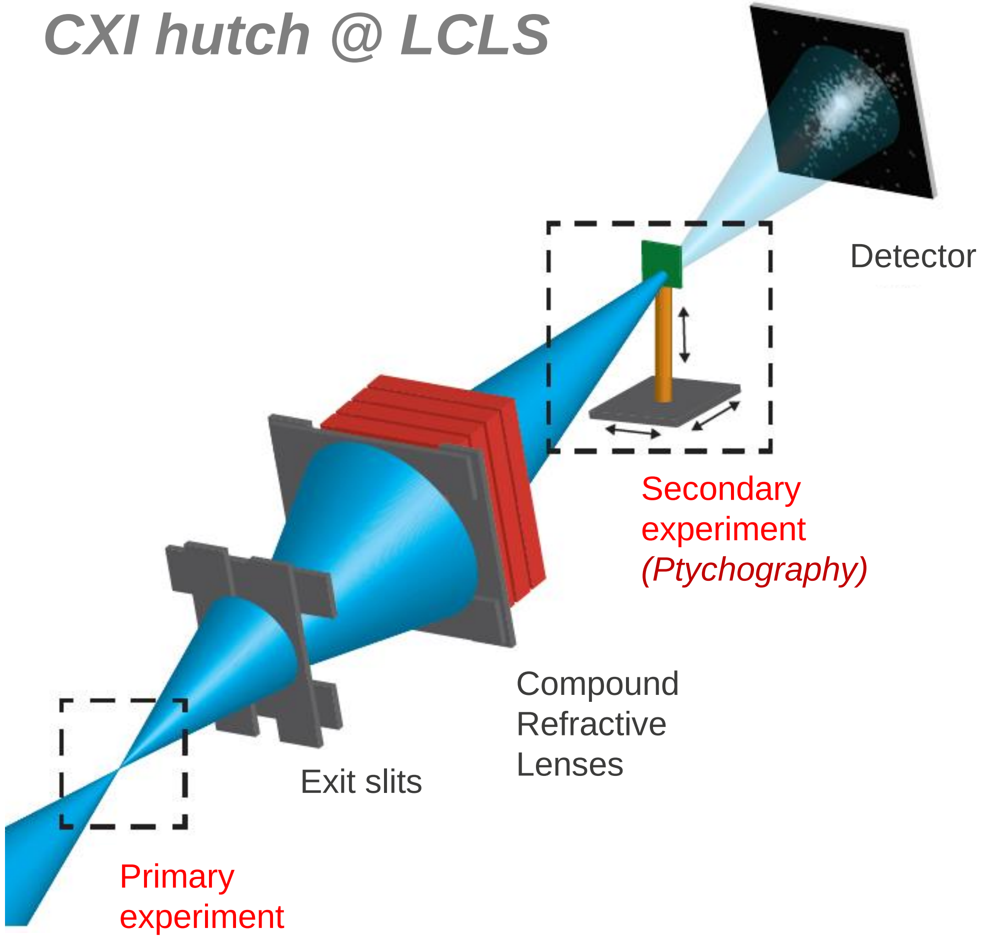
MaRIE KPP requirements

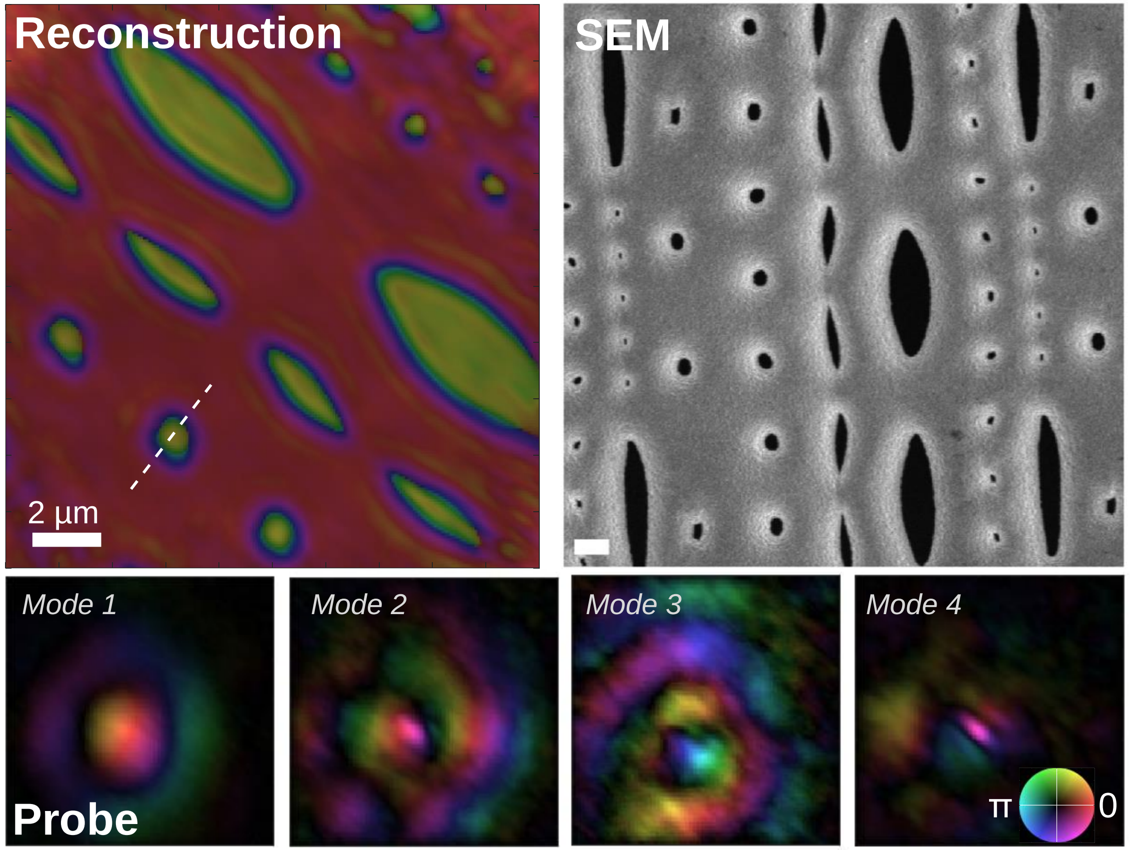
ASIC/Data	No. Chan.	Analog bandwidth (GHz)	digital sampling (GHz)	S/N (dB)	Bit Res.	CMOS technol.
PSEC4	6	1.5	15		10.5	IBM 130 nm
"Hawaii chip"	128?	3	20	58 dB/ 1Vpp	9.4	(TSMC 130 nm)
"Cornell Keck GHz"	384 x 256	0.5				
epixΔ	1M	3			>= 8	TSMC 250 nm

Backup

Parasitic Beam gives high quality ptychographic reconstruction

CXI hutch @ LCLS





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